Pressure Rise and Electron Cloud

S.Y. Zhang, RHIC Beam Experiments Workshop, October 15 - 16, 2003

I. Electron cloud induced pressure rise

1. Injection pressure rise associated with electron cloud
2. Bunch gap effect
3. Beam scrubbing
4. Solenoid effect
5. EC characteristics and simulation

II. Transition pressure rise

1. Proportional to total beam intensity
2. Experiment background affected, beam intensity limited
3. Transition pressure rise related to beam momentum spread
4. Halo scraping?
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III. NEG coated pipe in the RHIC

1. Reduced SEY and e - desorption help for EC type pressure rise
2. More concerned about ion desorption rate
3. Activation condition is important
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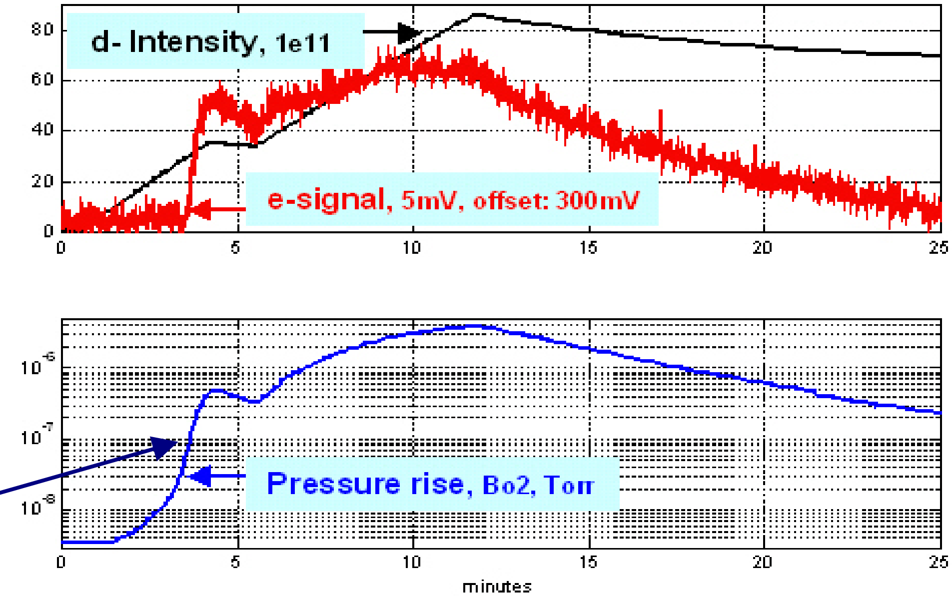
5. NEG coating test at Tandem

I. Electron cloud induced pressure rise

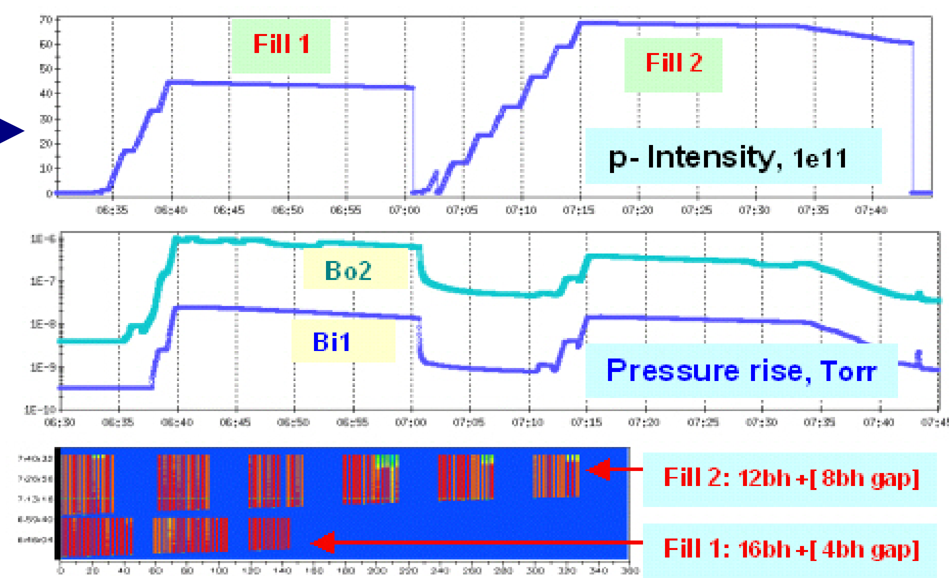
1. Injection pressure rise associated with electron cloud

- Close relation between inj. pressure rise and e- signal for d-Au and proton runs.
- Quantitative explanation is needed, by better electron detection and analysis.
- Pressure rise similar to e - signal, but it is in log scale.



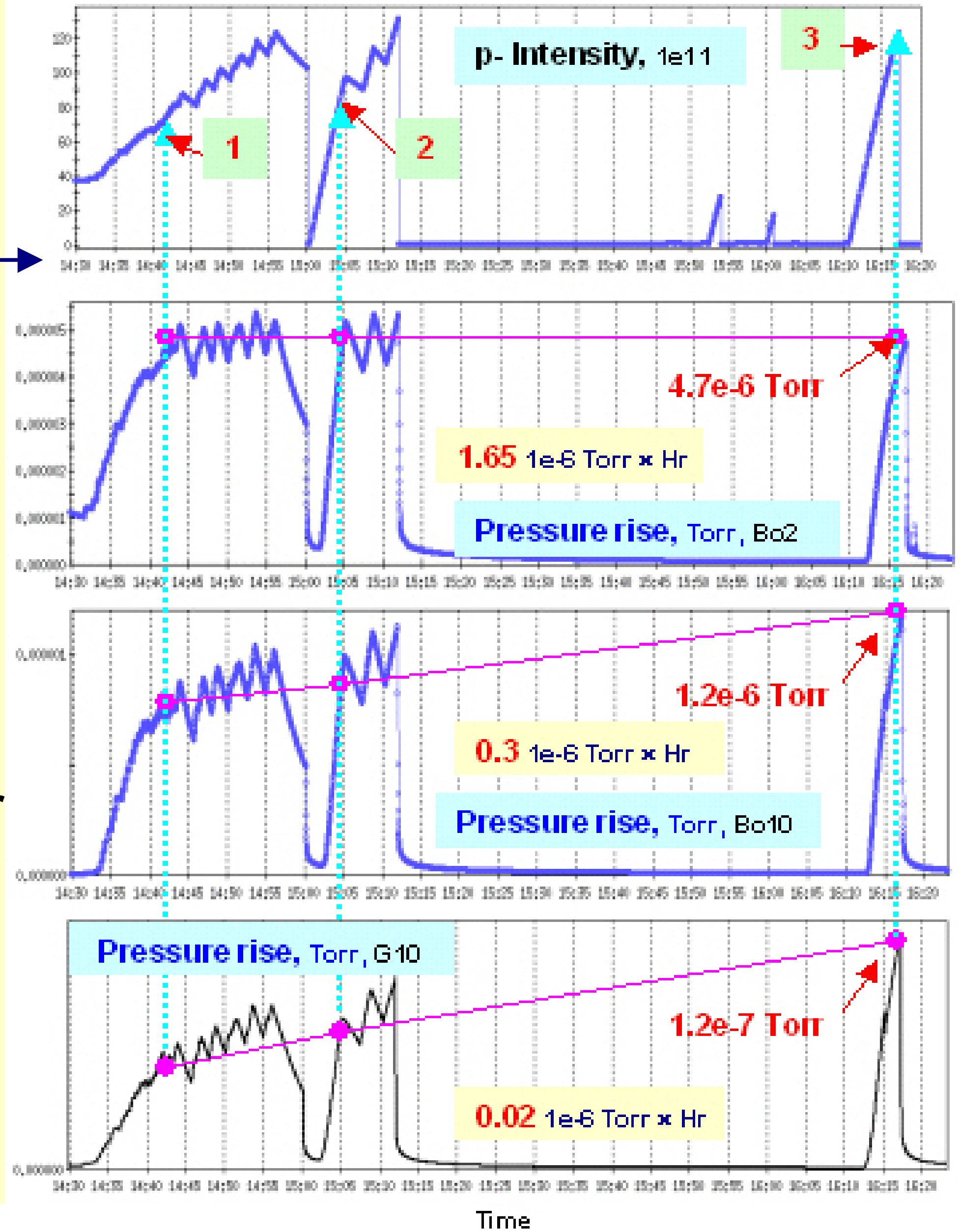
2. Bunch gap effect

- Proton 110 bunch mode, with bunch intensity ~ 1e11.
- Fill 1, 16 bunch + [4 bunch gap], intensity 45e11, with pressure rise 1e-6 Torr.
- Fill 2, 12 bunch + [8 bunch gap], intensity 70e11, with pressure rise 4e-7 Torr.
- Could be used in operation.



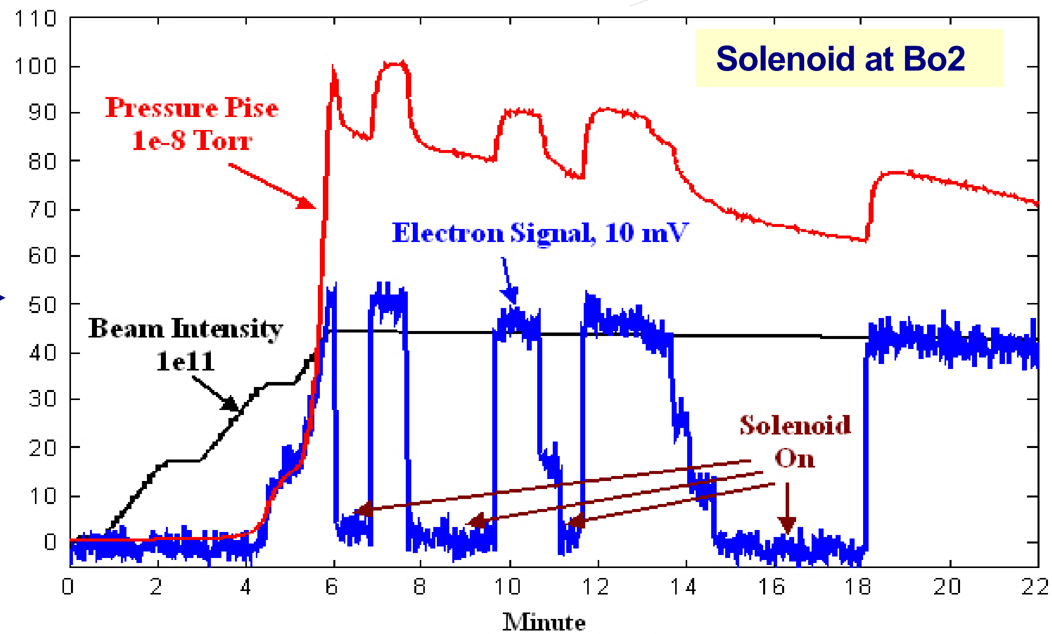
3. Beam scrubbing

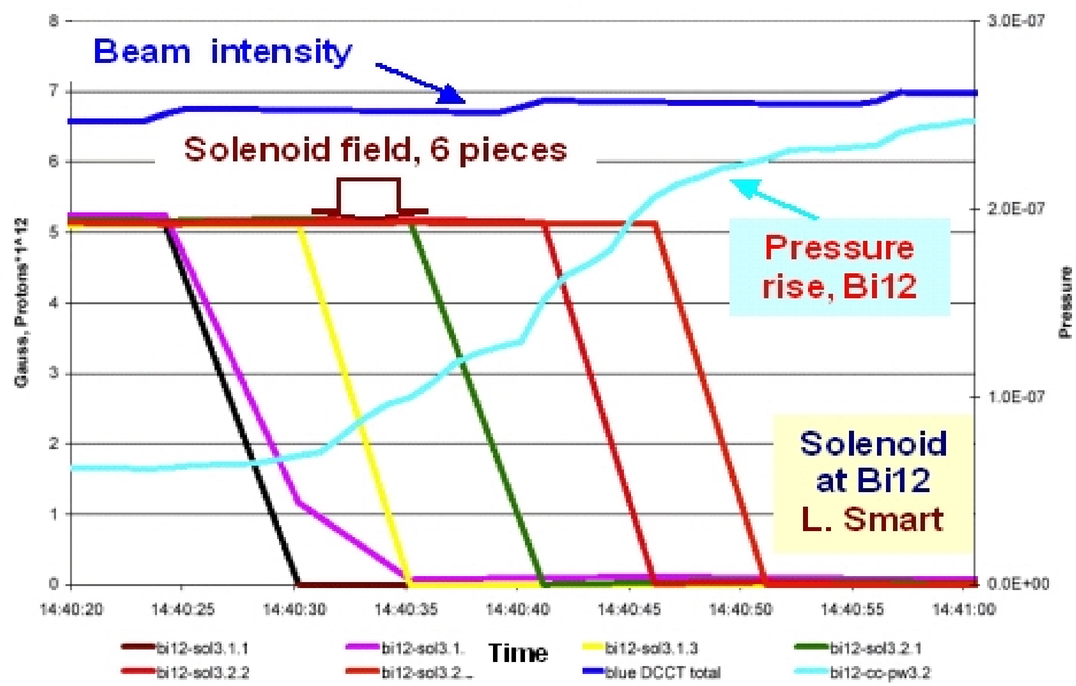
- **EC induced pressure rise itself is the beam scrubbing, as long as ≤ 5e-6 Torr, beyond that pumps are ineffective.**
- **Keep pressure rise of 5e-6 Torr at Bo2 for 20 minutes (planned 2 hour).**
- **1: intensity 80e11, 1.4e11/bh**
  2: intensity 92e11, 1.7e11/bh
  3: intensity 123e11, 1.7e11/bh, shorter bunch length
- **Bo2, total scrubbing 1.65 1e-6 Torr × Hr, some effect.**
- **Bo10, 0.3 1e-6 Torr × Hr, smaller effect?**
- **G10, 0.02 1e-6 Torr × Hr, no effect?**
- **SPS 24 hr scrubbing, pressure rise reduced by factor of 100, dose was ~ 120 1e-6 Torr × Hr.**



4. Solenoid effect

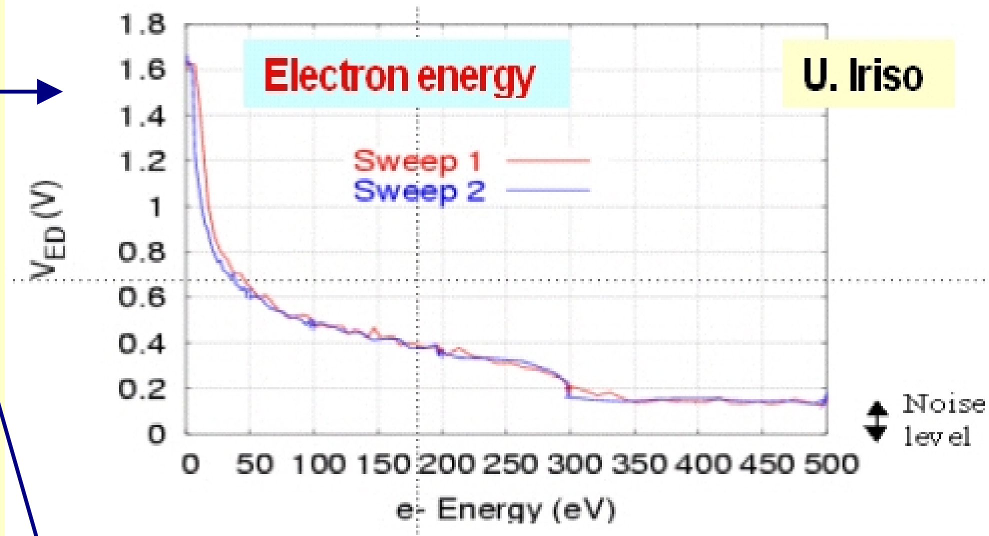
- At Bo2, 5 Gauss solenoid field, 4 m long, reduced pressure rise by ~ 20% in 34 meter pipe.
- Solenoid field at Bo2 also eliminated e - signal.
- Total 24 meter solenoids at Bi12 could not completely eliminate EC and pressure rise.
- Bunch intensity effect: at Bo2, 5 Gauss solenoid field suppressed electrons for bunch intensity of 1e11. For 2e11 bunch intensity, 67 Gauss field only partially suppressed electrons.
- Beam potential, solenoid location and field, pump and gauge effect.

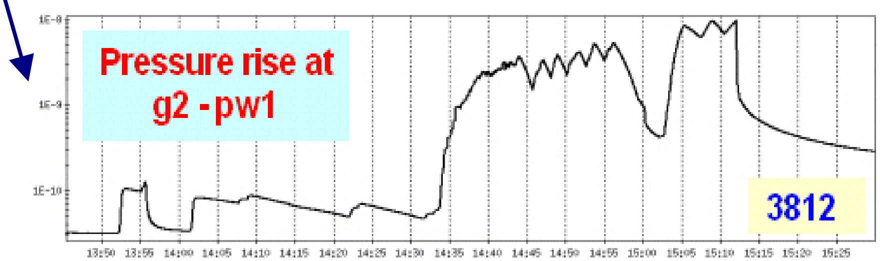


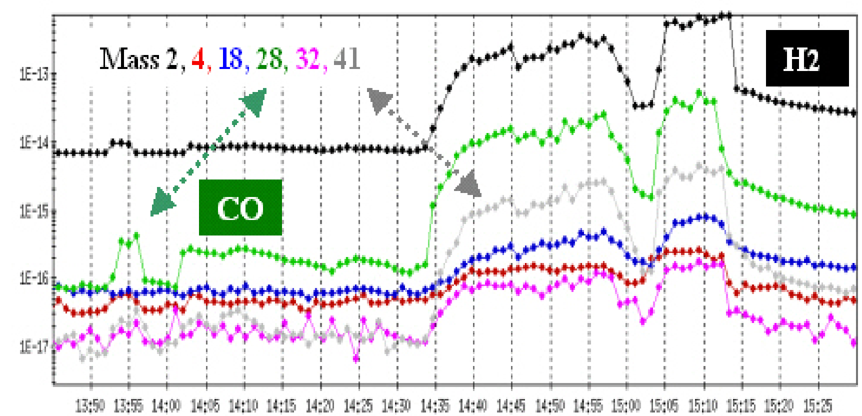


5. EC characteristics and simulation

- Electron energy spectrum, up to 300 eV, similar to other machine, e.g. PSR.
- RGA data shows significant contribution of CO at all level pressure rise, and heavier gases at high pressure rise.
- More functional RGA to help for further study, including the gas component evolution.
- Need new feature in simulation code to explain RHIC EC, with 216 ns bunch spacing and the dependence on locations.
- Incorporated with the beam study, simulation can be very helpful in predicting EC and pressure rise, in terms of beam intensity, bunch spacing, bunch gap, bunch length, and solenoid effect.



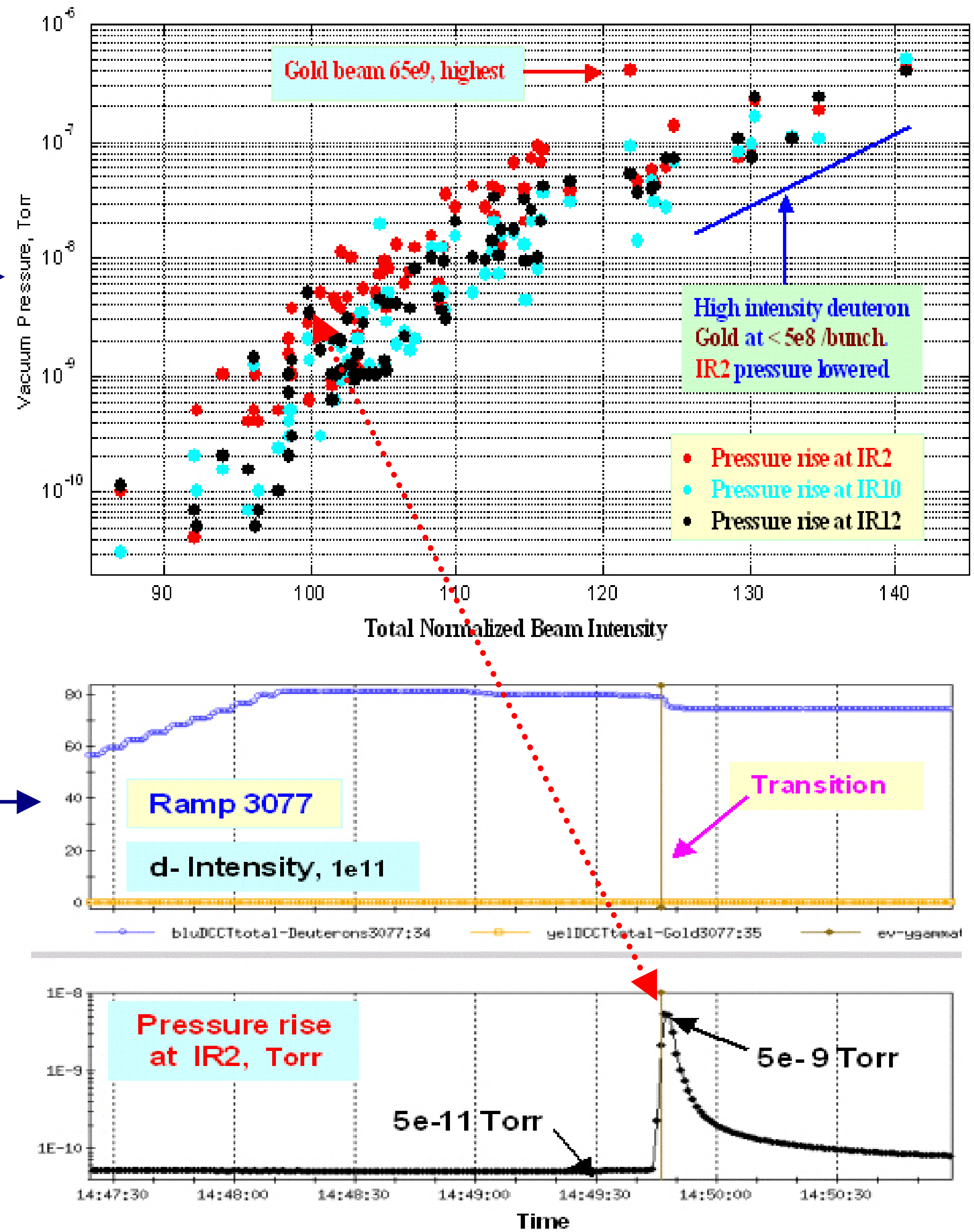




II. Transition pressure rise

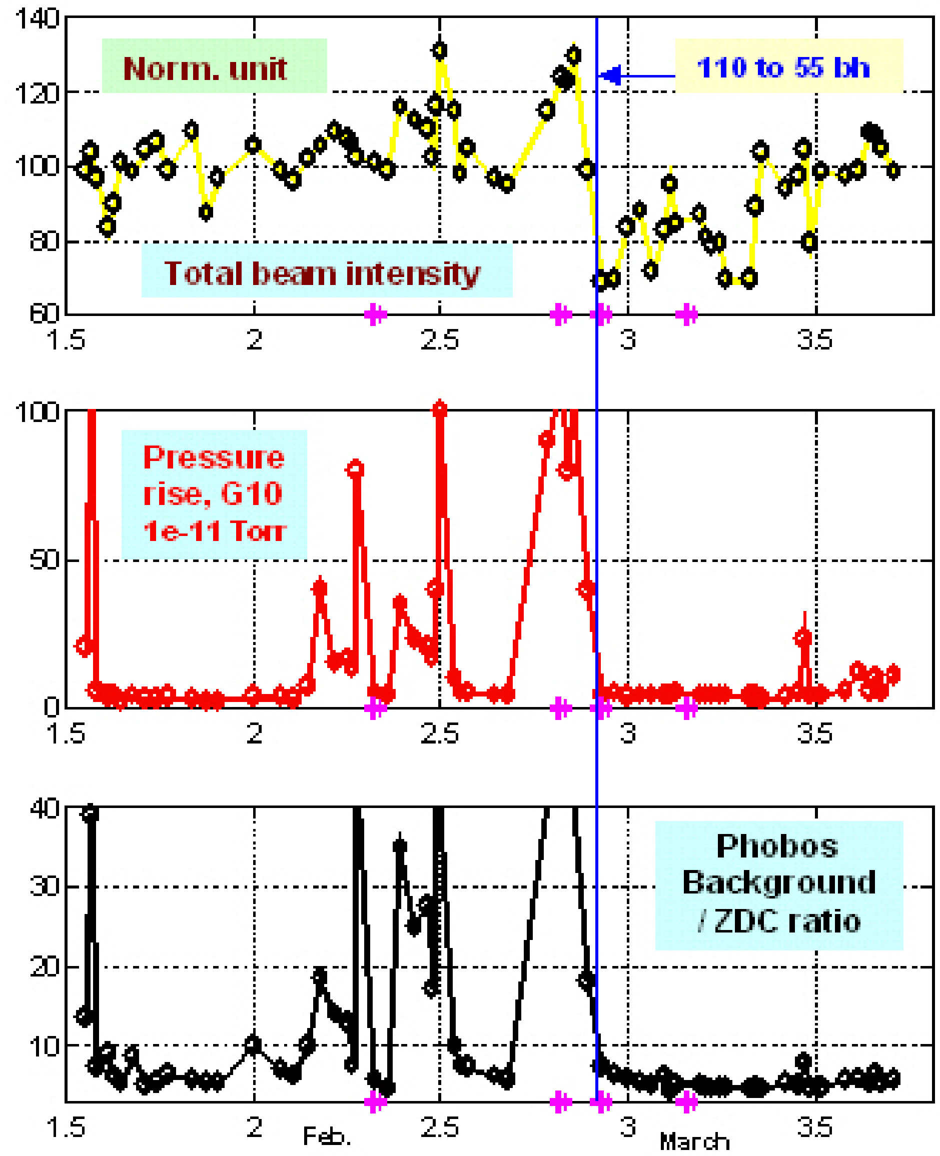
1. Proportional to total beam intensity

- Transition pressure rise quasi - exponentially proportional to total beam intensity.
- Normalized intensity unit equals charges of 1e9 Au ions.
- Both 55 bunch (up to 118 norm unit) and 110 bunch included, not sensitive to bunch spacing.
- A high intensity deuteron beam ramp also included.
- Not related to beam loss.
- Happened at IR and Q3 - Q4 straight sections.
- Not related to ion species.
- Highest Au intensity is 65e9.



2. Experiment background affected, beam intensity limited

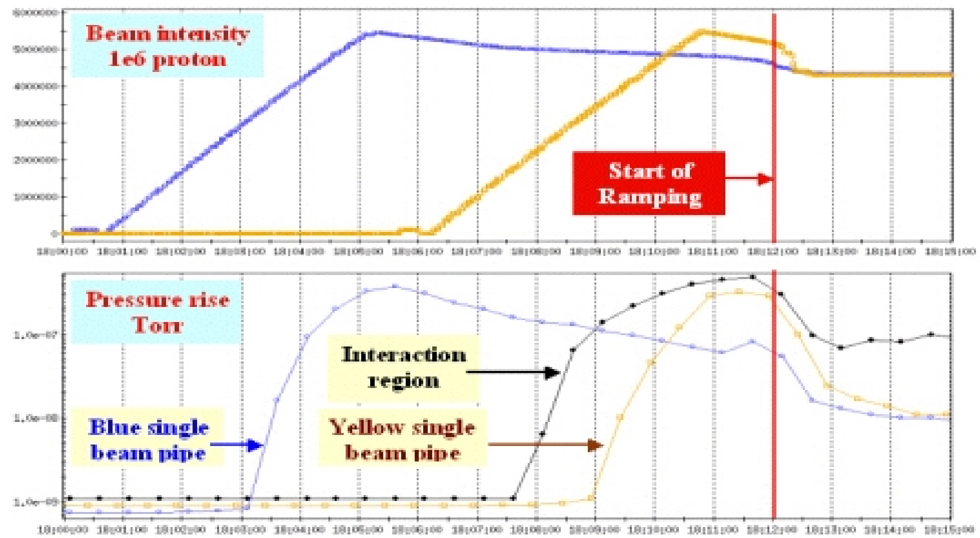
- In d-Au run, Phobos' background was seriously affected by high pressure rise, which was caused by high total beam intensity.
- Phobos pressure rise and background data taken 30 minutes after the transition. The pressure rise was the leftover of the transition pressure rise.
- For d-Au run, total intensity above 110 normalized unit induced high background.
- At 1e9 Au ions/bh, run4 with 56 bh may see background problem at the Phobos.
- No plan of 112 bh for run4.



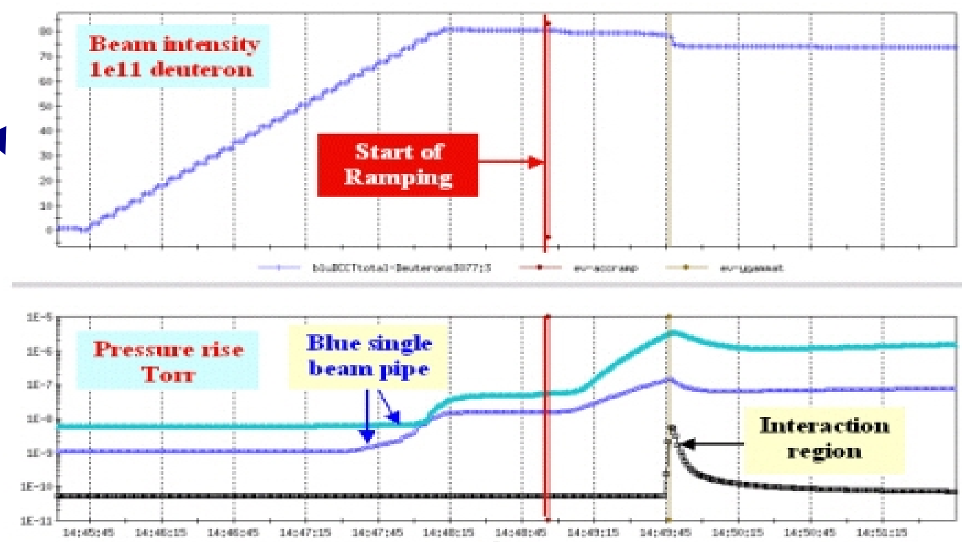
Intensity taken at transition, others 30 min. after transition

3. Transition pressure rise related to beam momentum spread

- In proton run, pressure rise decreased as ramp started. Because of reduced beam transverse size, or reduced beam momentum spread?
- In d-Au run, pressure rise increased as ramp started, and peaked at transition.
- Beam transverse size reduces in both proton and d-Au ramps.
- In d-Au ramp, beam momentum spread increased as ramp started, and peaked at the transition.



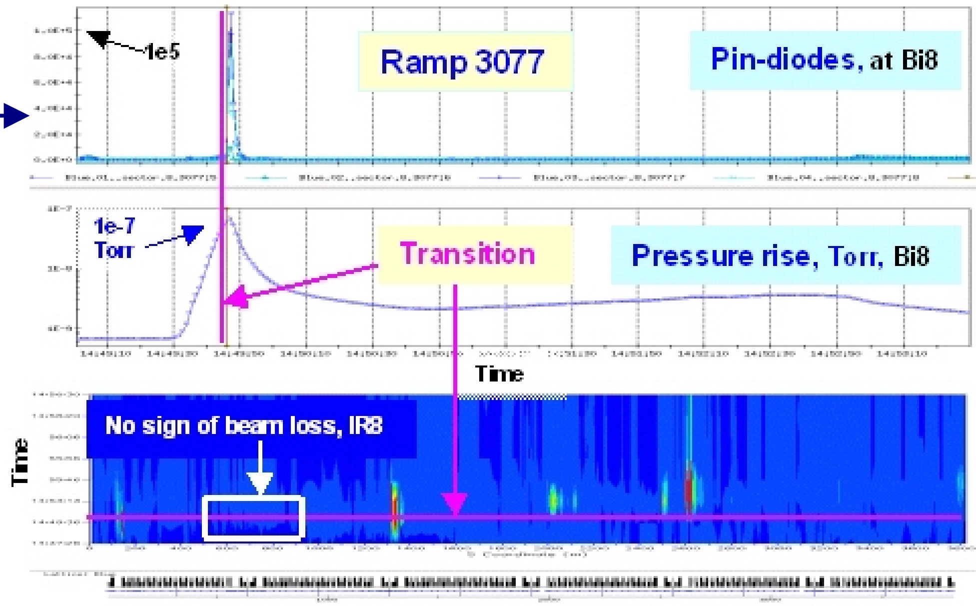
Proton run: pressure rise decreases as ramp started

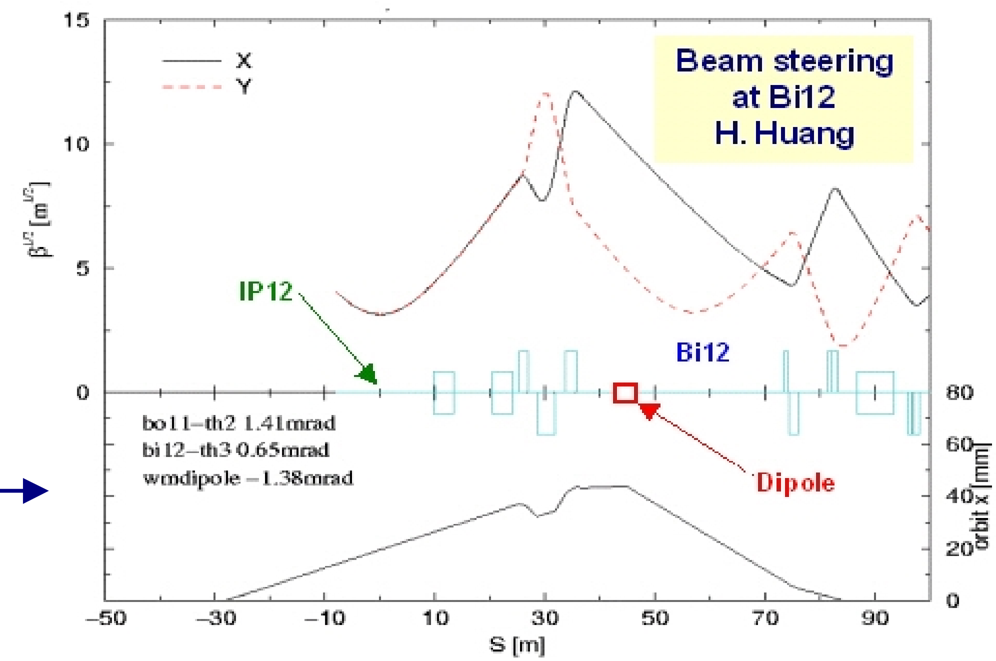


Au & d run: pressure rise increases as ramp started peaked to the transition

4. Halo scraping?

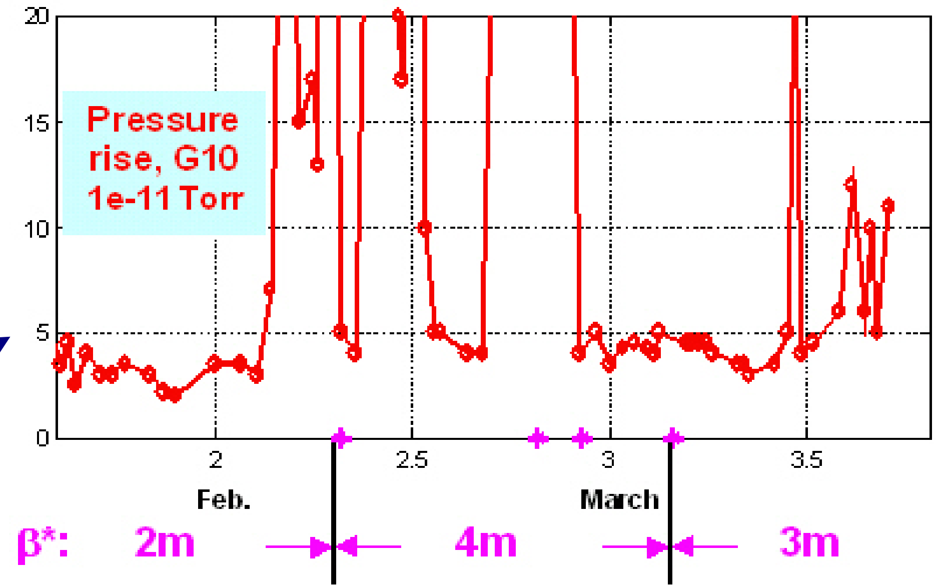
- Pin-diodes at collimation area Bi8 showed spike at the transition, for high intensity d-Au ramp, no sign of beam loss from beam loss monitor.
- The transition pressure rise of two order of magnitude implies large ion desorption rate.
- If confirmed, the transition pressure rise might be explained by halo scraping.
- It may also help to explain why RHIC EC happened at 216 ns: halo scraping created ion help electrons to survive bunch gap.
- Proposed beam scraping study: using dipole at Bi12 to steering the beam.

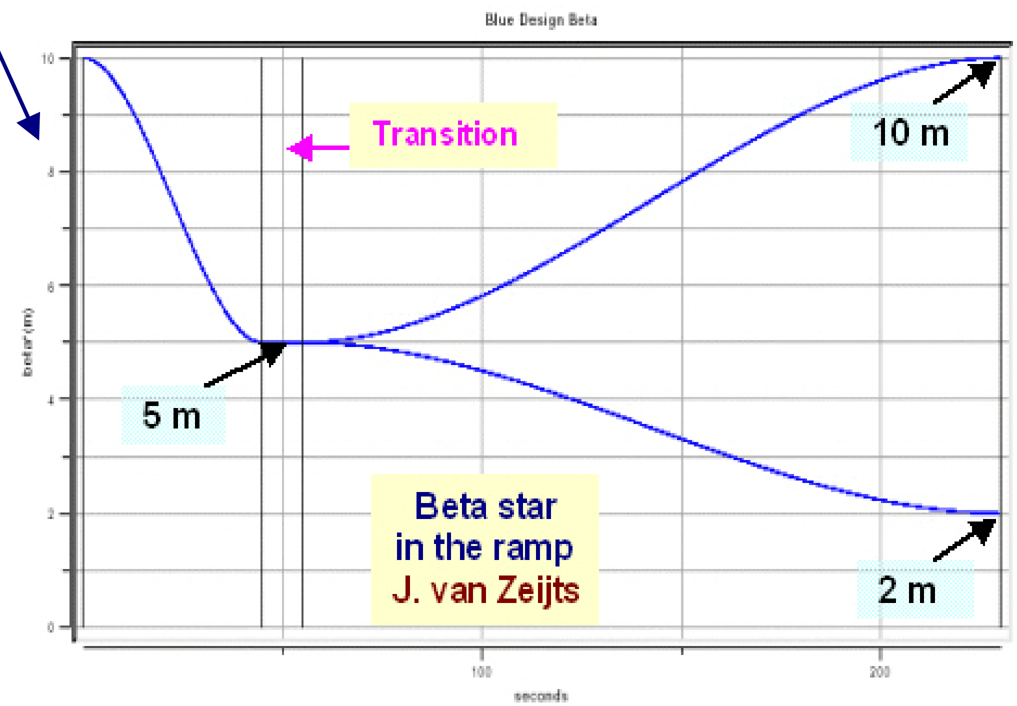




5. β* effect?

- In d-Au run, Phobos β* was increased from 2 m to 4 m, intended to reduce beam loss impact and to improve Phobos' background.
- The pressure rise data did not show much difference, probably due to unchanged β* at the transition.
- α1 and tune variation were main concerns to choose β*= 5 m at the transition.
- Improved beam loss at the transition in d-Au run shows that there might be some room.
- Transition β*= 8 m at the Phobos for study?
- Mitigate abort kicker aperture limit at transition?
- Negative impact?





III. NEG coated pipe in RHIC

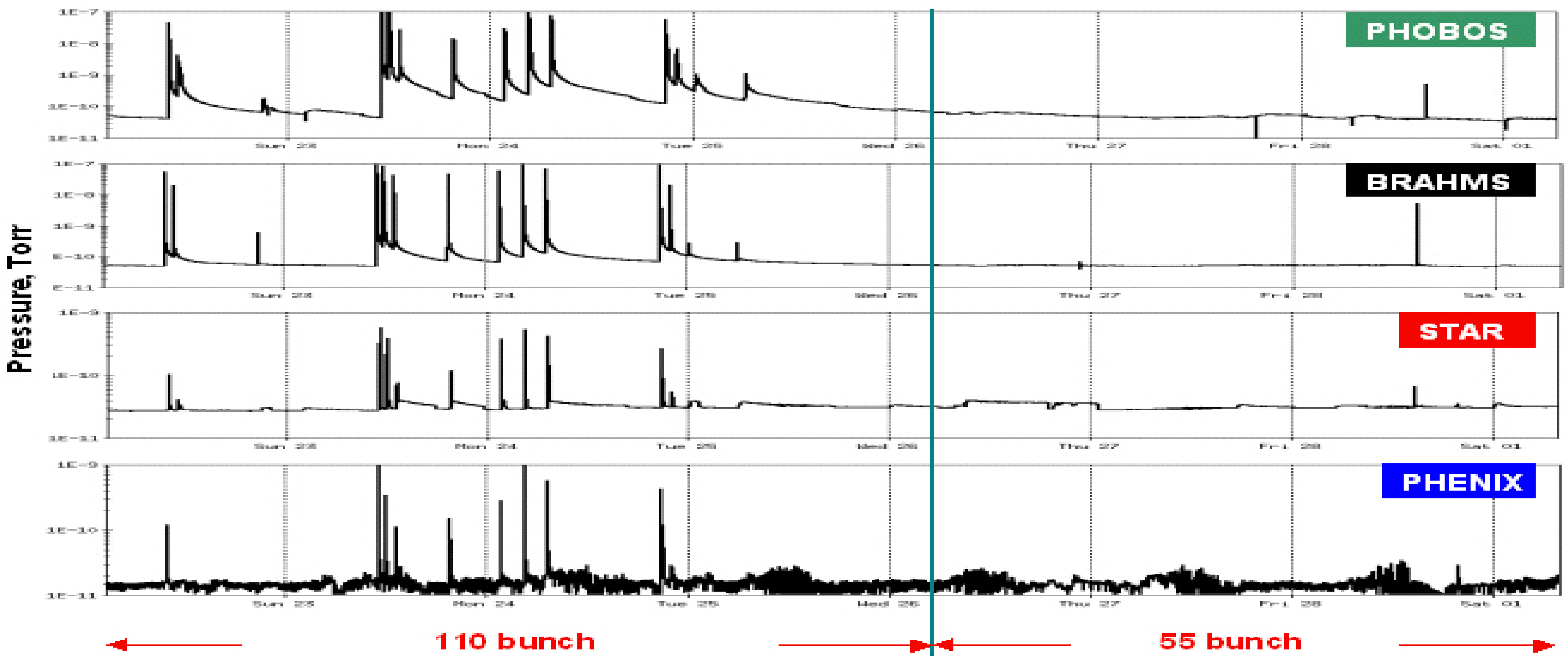
1. Reduced SEY and e - desorption rate help for EC type pressure rise

- Very rough NEG film helps for pumping (surface ~ bulk).
- EC type pressure rise benefited from by- product of the rough surface: much reduced SEY and e - desorption rate.

2. More concerned about ion desorption rate

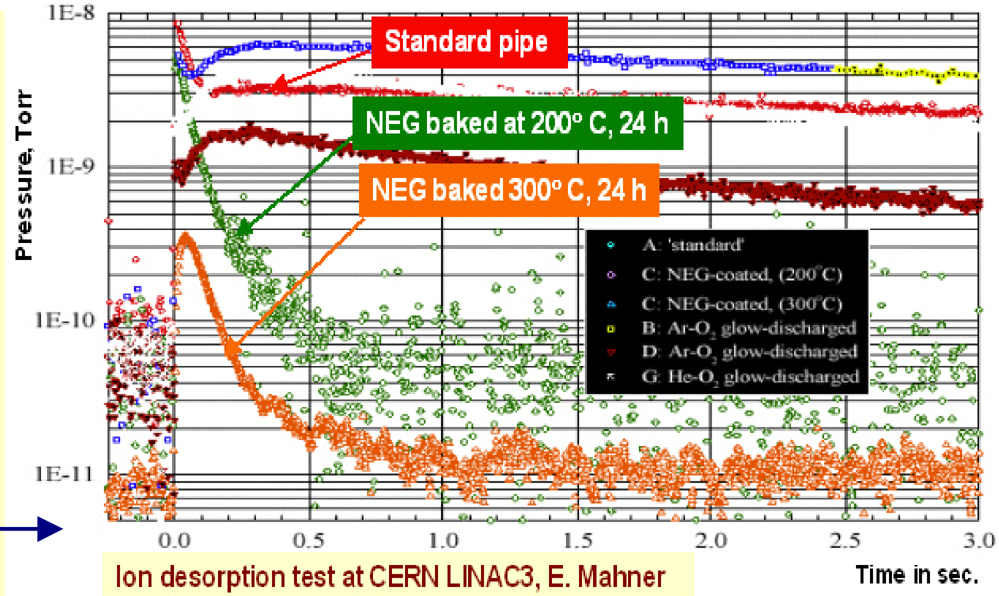
- Very limited experiment data, less margin.
- Unlike EC, no other effective countermeasures in sight.
- Might be limiting 112 bh operation.

Pressure rise at experiments - peaks are at the transitions



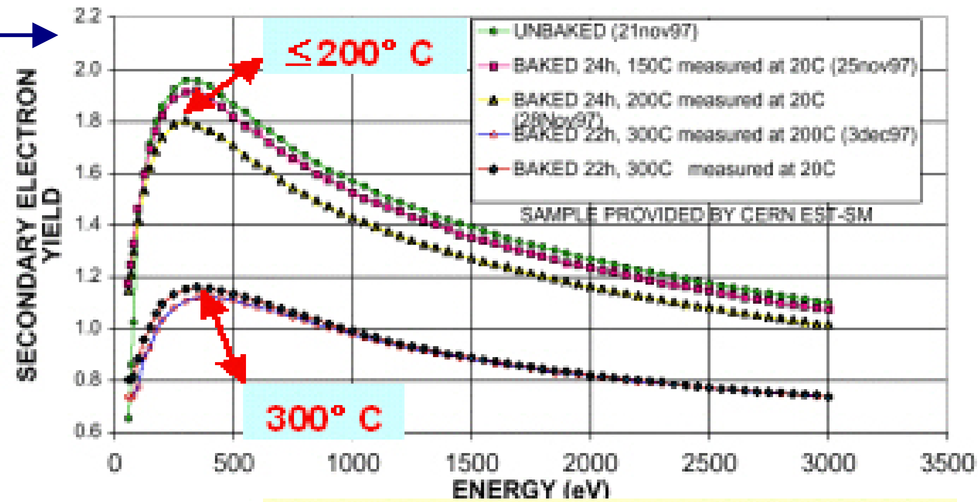
3. Activation condition is important

- Standard recipe: 180° C of 24 hrs, 200° C of 5 hrs, and 250° C of 2 hrs.
- Present plan in RHIC is 250° C of 2 hrs. Higher temperature and longer period imply more difficulties.
- CERN experiment showed big difference between activations of 200° C and 300° C, of 24 hrs, in both pumping and ion desorption rate.
- There might be big difference between activations of 200° C and 300° C, of 24 hrs, in SEY.
- Thresholds exist, for SEY, pumping, electron and ion desorption.
- Better experiment data exist, not always agreeable, but we cannot afford to take chance.



Ion desorption test at CERN LINAC3, E. Mahner

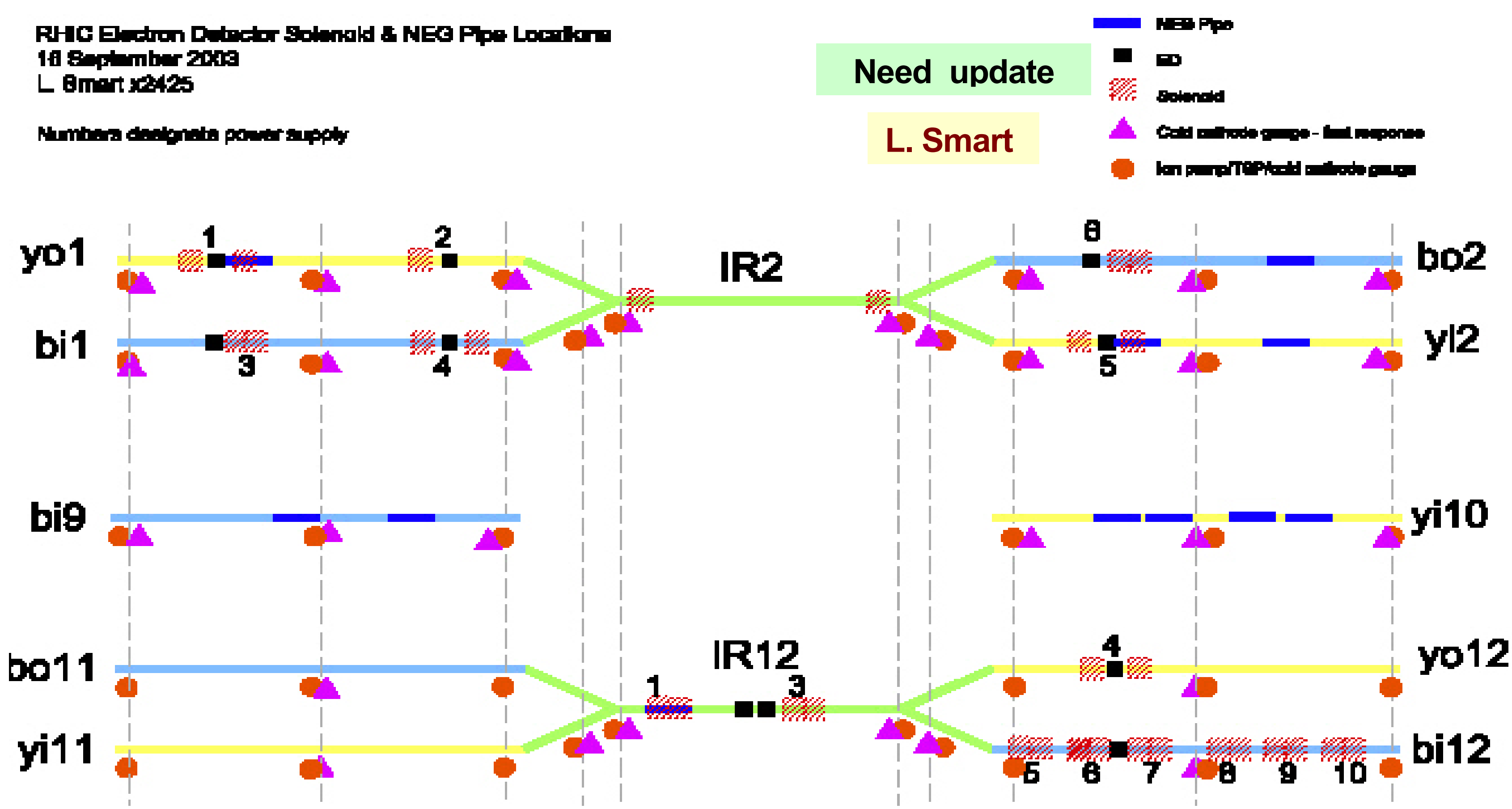
SECONDARY ELECTRON YIELD OF A GETTER LAYER



N. Hilleret, Two-Stream WKSP, 2001

4. NEG pipe (and other devices for study) in RHIC

- 11 NEG pipes, 5.2 m each, will be installed in RHIC ring.
- Main purpose is to verify its effectiveness for both EC and transition type of pressure rise.
- Others: solenoids with kapton wire and uniform field, two new solenoids at IR2, 14 gauges MADC upgraded, 7 amplifiers for ED, dipole at Bi12, Pin - diodes at Yo1 and Bi12.



5. NEG coating test at Tandem

- Verify the quality of NEG coating for RHIC.
- Main goal: ion - desorption rate of NEG coated pipe, at glancing angle beam scraping, at different activations, saturation.
- Plan to activate at 200° C, 250° C, and 300° C.
- Plan to use saturated NEG surface to overcome the complication come from the large pumping capability of NEG film.